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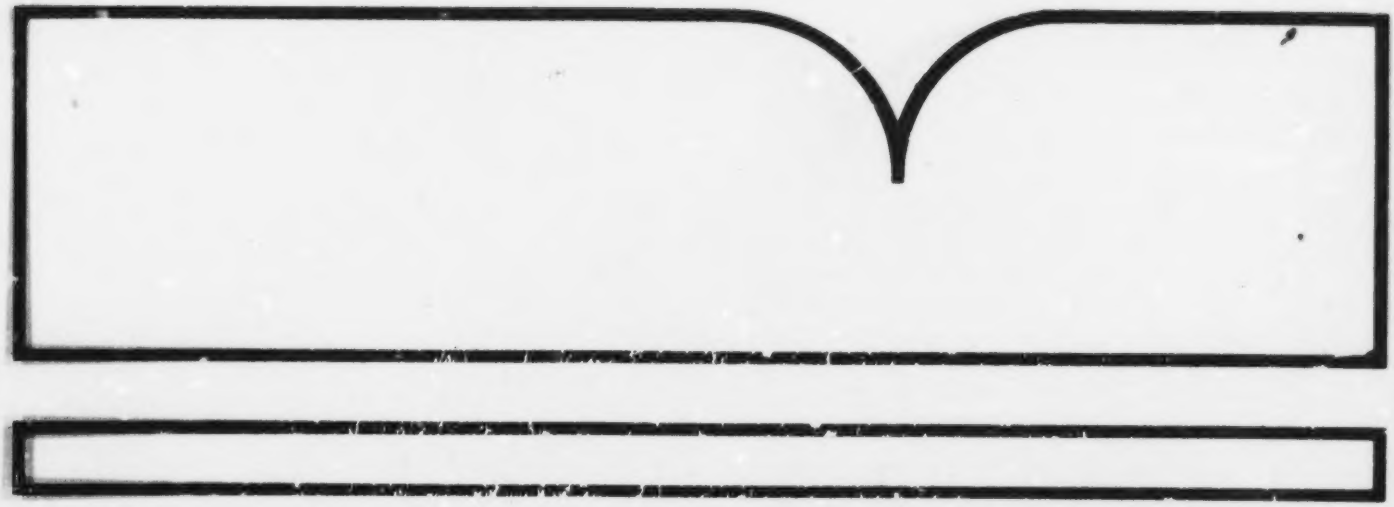

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16. ABSTRACT

Recreation demand and value are estimated with the travel-cost method for fishing, camping, boating, and swimming on a site-specific regional basis. The model is regional in that 197 sites are defined for the Pacific Northwest. A gravity model is employed to estimate the number of trips from each destination in the region, and these data are the basic input in the travel-cost demand curves. The model is illustrated by estimating the recreation benefits that would result from meeting the national environmental goal of "fishable and swimmable" rivers. The main finding is that potential recreation benefits are concentrated in a few select areas, which are accessible to large population centers.

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A Regional Approach to Estimating Recreation Benefits of Improved Water Quality

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Recreation demand and value are estimated with the travel-cost method for fishing, camping, boating, and swimming on a site-specific regional basis. The model is regional in that 179 sites are defined for the Pacific Northwest. A gravity model is employed to estimate the number of trips from each origin to each destination in the region, and these data are the basic input in the travel-cost demand curves. The model is illustrated by estimating the recreation benefits that would result from meeting the national environmental goal of "fishable and swimmable" rivers. The main finding is that potential recreation benefits are concentrated in a few select areas, which are accessible to large population centers.

INTRODUCTION

A methodology is developed in this study for estimating the recreation benefits of improved water quality at a single site, for numerous sites within a region and for an entire region. The Clawson–Knetsch travel-cost method (TCM) is a well defined methodology for estimating recreation-site demand curves. Applying the TCM to numerous sites is time-consuming and expensive because usually the entire analysis must be repeated for each site. Recreation planners and managers need the capability to estimate demand and value at a large number of individual sites. The model presented here generalizes the single-site travel-cost approach to reflect all sites within a region and can be used to estimate demand and value for any site within that region.

Empirical estimates are also provided of the recreation benefits that would result from achieving the national goal of "fishable and swimmable" water in the Pacific Northwest. A demand analysis of four water-based recreation activities is undertaken for 179 sites (or recreation centroids) in Washington, Idaho, and Oregon. Recreation-benefit estimates are presented by activity for each county in these states.

This analysis of recreation behavior differs from existing studies by virtue of magnitude, with 179 recreation centroids defined over three states. This scale is considerably larger than those in the regional models of Burt and Brewer [2], Cichetti *et al.* [10], Cesario and Knetsch [7], and Knetsch *et al.* [25]. The primary advantage of this size model is that any site within the three-state region can be analyzed. Also, the influence of all potential substitute sites is most likely to be reflected in a larger model. The ability to analyze a virtually unlimited number of sites results from the use of household surveys to estimate recreation trips by origin and a gravity model to estimate the distribution of these trips. Most recreation

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studies use site attendance data, which, at least for the Northwest, are deficient in both quantity and quality.

Most recreation analyses focus on one activity or treat recreation as a composite homogeneous good, for example, Stevens' [32] estimate of the fishing benefits resulting from improved water quality. In contrast, this analysis considers four activities: camping, fishing, boating, and swimming. A focus on one activity is inadequate when several activities may respond to water-quality improvement. Also, these four activities are not homogeneous. The activities differ in their response to site characteristics such as water quality, average travel distance and length of stay, and value per activity day. Furthermore, the relative composition of these activities varies widely across recreation sites.

The model is applied to estimate the change in recreation use and recreation value that would result if water quality were improved. In the Northwest, these recreation activities generally occur where water quality is high and where appropriate facilities are available. In those areas where water is degraded, recreation facilities have not been provided and recreation does not occur. Water quality and recreation facilities are complements and for purposes of this study are assumed to be perfect complements. Improved water quality will not stimulate recreational use unless there is a corresponding improvement of related recreation facilities such as swimming beaches, boat ramps, or campsites. Recreation facilities are not viewed as a true causal variable, but as a statistical proxy for a large number of nonquantifiable variables that, in combination, determine the attractiveness of a recreation site.[1] Fishing is the exception since no facilities are required. The site characteristic that is used to estimate the appeal of fishing destinations is the number of fishable-river miles and lake-shoreline miles. The exogenous variables that drive the model are linear swimming-beach feet, number of boat ramps, camping units and fishable-river and shoreline miles. An increase in any of these variables will increase demand and consumers' surplus, where it is implicit that water quality is "acceptable" for recreational purposes. Similarly, an improvement in water quality must be accompanied by an increase in one or more of the above variables if use and benefits are to be affected.

The model consists of four integrated components: a trip-production model, an attractiveness model, a trip-distribution (gravity) model, and a demand and valuation model. The trip-production model is used to estimate the number of recreation days by activity that emanate from each population centroid in Washington, Oregon, and Idaho. The attractiveness model is used to estimate the relative attractiveness of each recreation centroid in the region. Recreation days produced and attracted enter a gravity model where they affect the distribution of recreational travel. A gravity model estimates a trip-interchange matrix, which for each recreation centroid is the number of activity days received from each origin. These outputs are used to estimate a travel-cost demand curve for each recreation destination and for each of the four activities considered. Recreation value is measured as the area

[1]A report by the Institute of Transportation and Traffic Engineering [20, ch. 7] includes an effort to construct a recreation-attractiveness index for camping by defining 28 characteristics of campgrounds and applying factor analysis to select the most important factors. The factors that were selected accounted for 41.5% of the variance in the observed data. It is not feasible to apply a similar approach in this study because much of the required data do not exist, and the data that are available are of poor quality. The large-scale effort that would be required to complete the analysis is not justified by the improvement in the results.

under the demand curve and above the market price, which in this study is presumed to be zero. An improvement in water quality coupled with an increase in facilities produces an outward shift in the demand curve, and the area between the initial and new curve represents the benefits of improved water quality.

I. METHODOLOGY FOR ESTIMATING REGIONAL RECREATION BENEFITS

The methodology used to value water-quality changes is presented. Demand and valuation are discussed first, followed by the gravity model which is used to obtain inputs for the demand analysis. The trip-production and trip-attractiveness models are developed as inputs to the gravity model.

Recreation benefits of improved water quality are defined as the increment to consumers' surplus, or, net willingness to pay that result from a water-quality improvement. Benefits also can be defined as the sum of money that would give recreationists the same level of utility as the change in water quality. Improved water quality combined with increased recreation facilities results in an outward shift in the demand curve. The increment in willingness to pay is measured as the area between the new and original demand curves and above the market price. Empirical estimates of a recreation demand curve before and after a water-quality change are required to estimate incremental recreation benefits.

The conventional method of estimating a recreation demand curve was suggested originally by Harold Hotelling in a letter to the National Park Service, but is generally referred to as the Clawson–Knetsch travel-cost method (TCM).[2] Travel costs are used in lieu of market prices because the market price of recreation is frequently zero. A recreation-site demand curve is constructed by relating visit rates of population centroids to the corresponding travel costs.

The travel-cost methodology is used here to estimate benefits, but the algorithm for measuring consumers' surplus differs from what is typically used. Although travel-cost demand curves are estimated for each of four activities, the notation is simplified by assuming only one activity. Let T_i be the annual number of visitor days emanating from the ith population centroid and recreating at the site being analyzed, and let N_i be the population of the ith centroid. The demand curve for the recreation experience, or first-stage demand curve, is specified in semilog form

$$\ln(T_i/N_i) = \alpha + \beta C_i + \epsilon_i, \tag{1}$$

where C_i is the travel cost per person per visitor day from the ith zone.[3] Equation (1) was estimated for each of the four activities and for each of the 179 recreation centroids in the region. The regression estimates of this equation are used to generate site demand curves by taking antilogs and multiplying the equation by the population of the ith zone (N_i) to obtain

$$\hat{T}_i = N_i e^{\hat{\alpha}+\hat{\beta}C_i}. \tag{2}$$

[2] Of the numerous references on the travel-cost approach, Clawson [12], Knetsch [22, 23], and Dwyer *et al.* [16], are particularly good.

[3] The superiority of the semilog form over that of a double log is documented in Sutherland [33]. Ziemer *et al.* [39] present evidence in support of a semilog form versus a linear form.

By summing over all origins and allowing for hypothetical price changes we have

$$\sum_i \hat{T}_i = \Sigma N_i e^{\hat{\alpha} + \hat{\beta} C_i + \Delta P} \tag{3}$$

which yields an estimate of total visits as a function of population and the estimated visit rate of these populations.

Price–quantity observations for a demand curve can be obtained by substituting successive prices into (3) and solving for the corresponding quantity demand. The hypothetical price (ΔP) are in increments of \$1 from \$1 to \$4, \$2 from \$4 to \$12, \$4 from \$12 to \$76 or, until a successive price increment increases willingness to pay by less than 1%. Initially, \$1 price increments were used from \$0 to \$76, but experimentation showed that most of the consumers' surplus occurred at relatively low prices. Also extensive computer time is required because several computations are necessary for each of 716 (179 centroids $\times 4$ activities) first-stage demand curves. For these two reasons, the larger increments are used at higher prices. Quantity demanded at a zero price is estimated as ΣT_i, which is obtained from a gravity model. A recreation-site demand schedule could be obtained by estimating a best fitting line through these price–quantity data, where the quantities are generated from (3). Recreation value is usually estimated by integrating the resulting demand curve. In this analysis we are interested in total quantity demanded at a zero price and in recreation value, but not in the demand curve *per se*. A site demand curve is not estimated, but recreation benefits are estimated as the area beneath a polynomial which connects the prices and quantities generated from (3). Bode's rule is used to estimate this area.[4] Bode's rule is an algorithm for integrating a fourth-degree polynomial that would fit five points equally spaced on the horizontal axis.[5]

The data necessary to estimate a travel-cost demand schedule include visits or visit rates by origin and the corresponding travel cost. The travel-cost data include the travel distance from each population centroid to each recreation centroid, and the round-trip cost per person per vehicle mile. One-way travel distances are obtained from an impedance matrix, which is discussed below. According to the 1979 edition of "Principles and Standards," the cost per vehicle mile for a standard-size vehicle was 8.4 cents in 1976.[6] Using the Department of Commerce gas and oil price deflator, this figure was adjusted to 9.66 cents per mile for 1979. Next, 9.66 cents was doubled to adjust for round-trip costs and then divided by the average number

[4]For a definition of Bode's Rule, see Davis and Rabinowitz [14] or Abramowitz and Stegun [1].

[5]Consumers' surplus measured as the area under a function connecting the price–quantity observations would in general be quite close to the integral of a regression line. However, the estimate of quantity demanded at a zero price obtained from the gravity model differs from the estimate that would be obtained from (2) by letting $\Delta P = 0$. A regression estimate of a site demand curve and the integral of the estimate would be affected by the choice of quantity demanded at a zero price. By using Bode's rule, however, the choice of one price–quantity point affects only the area under the curve in the neighborhood of that point. The result that (2) does not accurately predict quantity demanded at a zero price is not widely recognized, but is probably a general characteristic of the TCM, not a result of the methodology used in this study. Furthermore, estimates of consumers' surplus are sensitive to the functional form of the demand curve, and there is mixed evidence on the appropriate functional form. The use of Bode's Rule resolves the functional-form problem because the implicit demand curve fits all the price–quantity observations. For an elaboration of these points and some evidence to support them see Sutherland [33].

[6]For an explanation of vehicle costs see [36, p. 72, 957].

of persons per vehicle (3.5) to obtain 5.52 cents.[7] The average length of stay is 1 day for swimming, boating, and fishing, but 2 days for camping; so 5.52 cents is divided by 2 to obtain mileage costs for camping activities. The recreation unit used in the state recreation surveys (discussed subsequently) and by the U.S. Forest Service is activity (or visitor) days, not trips or visits. Visitor days are the unit of measurement used here, although the distinction needs to be made only in the case of camping.

There is evidence for considering the time cost of travel in addition to the pecuniary cost. A neoclassical approach is to value time expended for travel as foregone earnings and hence to use the average wage rate as the monetary value of time. Cesario [6] reviewed several studies of commuting travel and concluded that the appropriate value of recreation travel time is approximately one-third the average wage rate. McConnell [27] asserts that the total time required to complete the activity is the appropriate consideration, not merely time in transit. Another possibility is that the time spent in recreation travel has positive utility and the travel-time "cost" is negative. The household recreation survey undertaken by the State of Washington in 1976 indicates that more people participated in driving for pleasure and sightseeing than any of the other 22 recreation activities.[8] Water-based recreation travel in the Northwest is often through mountains and forests and along rivers and may correspond more closely with driving for pleasure than commuting trips.[9] Recreation travel time may have a positive or negative value, but in this study a zero value is assumed.

Estimates of the number of visits to each recreation centroid from each origin are obtained from a gravity model. The gravity model is based on the hypothesis that the number of trips from origin i to destination j is proportional to the total number of trips produced at that origin and attracted to that destination and inversely related to the relative effect of spatial separation between the two zones. The specification of the gravity model employed here is written as

$$T_{ij} = P_i \frac{A_j F_{ij}}{\sum A_j F_{ij}} \tag{4}$$

and includes the constraints

$$\sum_j T_{ij} = P_i \tag{5}$$

$$\sum_i \sum_k T_{ijk} = \sum_k A_{jk}, \tag{6}$$

where i refers to origin, j to destination, and k to recreation planning region. In (4) T_{ij} is the number of activity days produced at i and attracted to j, P_i the number of activity days produced at i, A_j the number of activity days attracted to the jth recreation centroid, and F_{ij} a calibration term for interchange ij.

[7]The number of persons per vehicle is assumed to equal the mean family size, which is estimated (from census data) as the total population in Washington, Oregon, and Idaho divided by the number of families in those states.

[8]Interagency Committee for Outdoor Recreation [21, p. IV. 16].

[9]The recreation activities considered here occur primarily as one-day trips or (for camping) weekend trips. Total time available for travel and recreating is a constraint where the opportunity cost of travel time is foregone time available for recreating. Foregone earnings are not an appropriate valuation measure of recreation travel time, at least under the conditions in this study.

The gravity model is a distribution model; it takes a given number of recreation activity days emanating from population centroids and distributes these days according to the relative attractiveness and spatial impedance between centroids. As noted by Ewing [17], Eq. (4) has two important properties. Adding destinations to the system or increasing the attractiveness of the existing destinations will increase the number of trips to that destination, but at the expense of alternative destinations. That is, the total number of trips is exogenous. Second, the model allocates trips by considering the substitutability between recreation centroids, a property particularly important for recreation analysis. The proportion of trips emanating from i with destination j is a function of the attractiveness and spatial impedance of destination j relative to that of all alternative recreation centroids in the system.

Gravity models are generally calibrated by an iterative technique where the resulting trip interchange matrix (T_{ij}) satisfies certain constraints. Generally, the sum of the columns of T_{ij} must equal exogenous trip productions; the rows must sum to exogenous attractions and the trip-length frequency distribution implied by T_{ij} must conform to a known distribution. The trip production constraint is defined by (5) and the trip-length frequency distribution is discussed subsequently. In this study attractions are balanced over each recreation planning region rather than at each recreation centroid. These regions have been defined by the respective states and generally consist of from 2 to 5 neighboring counties. In addition to estimating the allocation of trips, the gravity model estimates total use at each destination, subject to the constraint that use over a planning region balances with exogenous attractions. The significance of (6) is that use by centroid is endogenous and therefore reflects the influence of substitute sites.[10]

Gravity models have appeared in the recreation literature, but with objectives and specifications different from those in this study. For instance, Cesario [3–5] presents a gravity model for generating and distributing recreation trips. Cheung [8], like others, used it to explain observed recreation behavior and found the model to have relatively high explanatory power ($R^2 = 0.84$). The gravity model is used here, not to explain observed behavior, but to estimate a trip interchange matrix (T_{ij}), which is an input in estimating a large number of travel-cost demand schedules. Each column vector in T_{ij} estimates the number of recreation activity days produced at origin i with a specific recreation destination. In this study $j = 1, \ldots, 179$ so 179 demand curves can be estimated for each of four activities. Since destinations can be added to the analysis, the model potentially can estimate a demand curve and recreation value for each of four activities at any site in the region. The construction of the gravity model input data is explained below.

Travel distances are contained in an impedance matrix (I_{ij}) that lists the minimum driving distance from each population centroid to each recreation centroid in the three-state region. This matrix was estimated by first defining the population and recreation centroids of each county, and where appropriate, multirecreation and/or multipopulation centroids were used per county. There are a total of 119 counties in Washington, Oregon, and Idaho, but there are 132 internal-population centroids and 179 recreation centroids. In this model the remainder of the United States and Canada is divided into 12 external zones, so there are a total of 144 population (origin) centroids. After each centroid was defined and located on a highway map, a

[10]The gravity-model calibration procedure is discussed in transportation-engineering texts such as Dickey [15, pp. 201–207] and Hutchinson [19, pp. 88–97].

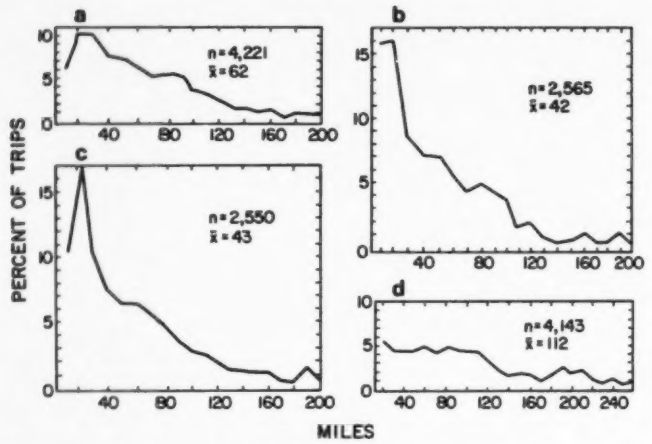

FIG. 1. Relative frequency distributions of (a) fishing, (b) boating, (c) swimming, and (d) camping. Note: n is the sample size, $\bar{x}$ is the sample mean distance per trip.

network was constructed to show distance between intersections along major roads. Possible routes from each population centroid to each recreation centroid were thereby identified. A computer program was used to solve for the minimum driving distance between each population and recreation centroid. The resulting travel distances constitute a 144×179 impedance matrix. Each column vector in this matrix denotes the minimum one-way mileage from each population centroid to a specific recreation centroid. These column vectors are inputs in the travel-cost demand curves and the impedance matrix is an input in the gravity model.

The F_{ij} terms in (4) are friction factors, which are constructed from the impedance matrix and trip-length frequency distributions. The F_{ij} terms reflect the influence of distance on the length of trip and can be defined as the probability of driving from population centroid i to the jth recreation centroid. In 1976 statewide recreation surveys were taken in each of the three northwest states. The household surveys contain data on the number of recreation trips by type and trip origin and distance or destination. The impedance matrix was used to convert origin–destination data to travel distances. These distances and the corresponding number of trips were used to form a trip-length relative frequency distribution for each of the four activities. These frequency distributions are also termed decay curves and can be interpreted as probability functions of trip distances. Figure 1 depicts the estimated decay curves for the four activities. These decay curves were estimated by the smoothing equation

$$F_e = 0.8F_0 + 0.2F_{0-1},$$

where e means estimated, 0 is observed, and -1 refers to the previous travel distance. The main use of these decay curves is to transform impedance values into the F_{ij} matrices. By substituting each impedance value into the four decay curves, an F_{ij} matrix was constructed for each activity.

Estimates of recreation trips produced by origin and by type of activity were constructed with data obtained from three statewide recreation surveys.[11] Recreation

[11]Data tapes containing raw survey results were obtained from each of the three states.

trips produced by origin are postulated to be a function of population, demographic characteristics of the population, the accessibility of recreation centroids, and the state of residence.

Accessibility of recreation areas is defined as a function of the availability of facilities, and the probability of traveling the necessary distance to these facilities. As explained above, the F_{ij} terms estimate the probability of traveling from i to j. The accessibility of population centroid i (PA_i) for one activity is estimated by summing recreation facilities (Fac_j) over all recreation centroids weighted by the probability of driving the corresponding distances. That is,

$$\mathrm{PA}_i = \sum_{j}^{179} F_{ij}\mathrm{Fac}_j, \tag{7}$$

where PA_i measures the accessibility of recreation opportunities of the ith population centroid.

Recreation activity days produced by origin are estimated by first estimating the average number of trips per person and then multiplying by the population of the origin. Recreation activity days per person are estimated as a function of the demographic variables: age Ag, age squared Ag^2, sex S, income Y, and the accessibility of population centroids PA_i. The three state household surveys were undertaken separately and different questionnaires and sampling methods used. To allow for the possibility that variations in response between states are influenced by the different survey or sampling methods, a dummy variable is used to define the state of a person's residence. The dummy variables are W for Washington, O for Oregon, and I for Idaho.

The method used here to estimate recreation days per person was used originally by Davidson *et al.* [13], and subsequently by Cicchetti *et al.* [11]. Each respondent was first determined to participate or not participate in a particular activity and second, if the respondent participated, the number of days participating was noted. The trip-production model has two components. The first component uses a zero–one variable as the dependent variable and estimates the probability of participating. The second component estimates the frequency of participation of those who participate. In general form, the trip-production model is

$$\left.\begin{matrix} PR_i \\ NR_i \end{matrix}\right\} = f\left(\mathrm{Ag}_i, \mathrm{Ag}_i^2, S_i, Y_i, \mathrm{PA}_i, W, O, I\right) \tag{8}$$

where PA_i is estimated by (7), and where PR_i denotes the probability of participating and NR_i denotes the frequency of participating.

Equation (8) was estimated using ordinary least squares with PR_i as the dependent variable and again using NR_i as the dependent variable.[12] Several coefficients

[12]OLS estimates of a dichotomous dependent-variable model are subject to the limitation of a heteroskedastic disturbance term, which nullifies the use of the t test. Furthermore, the estimated probabilities may be outside the feasible one–zero range. Logit and probit estimators overcome these limitations and are generally agreed to be superior to OLS at the conceptual level. Smith and Cicchetti [30] state that computational costs for logit and probit analyses are greater than for OLS when data sets are large (in excess of 100 observations). The sample size in my study exceeds 5000. The most compelling case for using OLS to estimate a dichotomous dependent variable model is that the estimates tend to be similar to those obtained using logit or probit. Evidence to this effect is provided by Williams and Smith [38], Watson [37], and Smith and Munley [31], among others. The similarity of estimates is particularly likely in the present case because of the low explanatory power of the model and because the estimated probabilities are not near the extreme zero or one values.

are insignificant. Since the main objective of these equations is to obtain a model that can be used to estimate trips produced by centroid, the model should include only significant variables. The model was again estimated by including variables that were significant at the 10% level. The results are presented in Table I. The demographic variables are generally significant and of appropriate sign when the dependent variable is a dummy, but not when it is the number of days participating. The accessibility variable is insignificant in seven of the eight equations.[13] The implication is that those who reside near recreation opportunities do not have a higher propensity to recreate than those who do not have such opportunities; and further that the increase in recreation demand at improved sites must come at the expense of existing sites. This conclusion must be viewed tentatively and may be a consequence of inconsistencies in the surveys undertaken by the three states.

The other two noteworthy results in Table I are the low R^2 values and the highly significant dummy variables representing the state of residence. The low R^2 values were expected because similar values have been obtained by other studies (Davidson *et al.* [13]; and Cicchetti [9]). Since recreation days are estimated by aggregating across individuals, random variation between individuals is likely to cancel out. Therefore, the low explanatory power of the model does necessarily introduce a significant error in county participation days. The significance of the state dummy variable is of concern because state boundaries should not determine recreation behavior. This result, like that of the insignificant accessibility coefficients, may be a result of inconsistencies between the three state surveys.

The regression estimates in Table I were used to estimate recreation days by activity for each county in Washington, Oregon, and Idaho. County population data by demographic characteristic were substituted into Eqs. (8.5)–(8.8) to estimate the expected number of participants by activity in each county. These data were also substituted into participation-frequency equations, (8.1)–(8.4), to estimate the expected number of days that participants recreated. Recreation days by activity and by county are estimated as the product of the number of recreators and their frequency of participation. In essence, though, recreation days by county are approximately proportional to county population, but are adjusted to reflect demographic characteristics of the county residents and their state of residence.[14]

The gravity model also requires an estimate of the attractiveness of each recreation centroid. Attractions are postulated to be an exponential function of recreation facilities and the accessibility of the recreation centroid, which measures the likely demand pressure on that centroid. At least in the Northwest, utilization rates at recreation sites tend to vary inversely with the distance to population centers. The responsiveness of attractions to changes in facilities should therefore be positively related to the nearness of these facilities to population centers. Furthermore, attractions should respond to increments in facilities at a diminishing rate. The attractiveness model is specified in exponential form to allow for the diminishing-returns effect and the interaction between facilities and accessibility.

Accessibility of recreation centroids is measured differently from the accessibility of population centroids, but the underlying concept is the same. The accessibility of a recreation centroid is a function of the number of trips produced by each

[13]The accessibility index was significant but negative in (7). Since this result cannot be rationalized theoretically, the equation was reestimated after omitting the accessibility variable.

[14]In those counties with multiple population centroids, county recreation days were allocated among centroids on the basis of centroid population.

TABLE I

Regression Results of Recreation Participation Behavior

Equation number	Dependent variable	Intercept	Age	Age^2	Sex	Income	Rec. Acc.	Washington	Idaho	Oregon	R^2 $\bar{y}$	F SER
8.1	Swim	37.52	−106.71	114.32	−3.14	21.10		−18.05			0.066[5]	646.65
	Days	(6.10)	(−3.26)	(2.77)	(−1.76)	(3.01)		(−6.58)			21.31	32.42
8.2	Camp	1.64	5.36							4.58	0.089	942.08
	Days	(2.94)	(4.31)							(11.95)	5.84	8.37
8.3	Fish	12.69			2.79			−9.97			0.056	683.65
	Days	(19.09)			(2.96)			(−9.45)			11.50	19.00
8.4	Boat	10.99				10.53		−11.24			0.03	394.51
	Days	(4.22)				(6.00)		(−6.11)			13.31	25.83
8.5	Swim	0.97	−2.28	1.41	−0.02	0.33	0.002	−0.250		−0.061	0.25	2821.1
	Dummy	(21.27)	(−10.24)	(−5.79)	(−1.69)	(7.22)	(2.22)	(−13.59)		(−2.95)	0.29	0.39
8.6	Camp	0.56	−0.59	0.02		0.38		−0.18			0.10	3472.2
	Dummy	(18.45)	(−14.05)	(1.71)		(7.78)		(−11.86)			0.38	0.46
8.7	Fish	0.16		−0.28	0.11	0.31			0.25	0.09	0.08	3191.3
	Dummy	(5.38)		(−5.92)	(7.56)	(6.01)			(13.84)	(5.16)	0.37	0.46
8.8	Boat	0.73	−2.03	1.54	0.03	0.46		−0.20		−0.06	0.15	2112.3
	Dummy	(15.95)	(−8.85)	(6.17)	(2.51)	(9.97)		(−12.26)		(−4.11)	0.26	0.41

Note. The dependent variable in Eqs. 8.1–8.4 is the number of participation days, given that this number is nonzero. The numbers in parentheses are t values. Age, income, and recreation accessibility have been divided by 100 to produce comparable units with the dependent variable. The independent variables, Washington, Oregon, and Idaho are dummy variables. At most, two states would enter the model because if all three dummy variables were entered, the sum of these three column vectors would be a vector of ones and would be identical to the intercept column vector. R^2 is the coefficient of determination, $\bar{y}$ is the mean of the dependent variable, SER is the standard error of the regression equation, and F is the F statistic. Population data were obtained from the U. S. Bureau of Census [35].

TABLE I

Regression Results of Recreation Participation Behavior

Equation number	Dependent variable	Intercept	Age	Age^2	Sex	Income	Rec. Acc.	Washington	Idaho	Oregon	R^2 $\bar{y}$	F SER
8.1	Swim	37.52	−106.71	114.32	−3.14	21.10		−18.05			0.066[5]	646.65
	Days	(6.10)	(−3.26)	(2.77)	(−1.76)	(3.01)		(−6.58)			21.31	32.42
8.2	Camp	1.64	5.36							4.58	0.089	942.08
	Days	(2.94)	(4.31)							(11.95)	5.84	8.37
8.3	Fish	12.69			2.79			−9.97			0.056	683.65
	Days	(19.09)			(2.96)			(−9.45)			11.50	19.00
8.4	Boat	10.99				10.53		−11.24			0.03	394.51
	Days	(4.22)				(6.00)		(−6.11)			13.31	25.83
8.5	Swim	0.97	−2.28	1.41	−0.02	0.33	0.002	−0.250		−0.061	0.25	2821.1
	Dummy	(21.27)	(−10.24)	(−5.79)	(−1.69)	(7.22)	(2.22)	(−13.59)		(−2.95)	0.29	0.39
8.6	Camp	0.56	−0.59	0.02		0.38		−0.18			0.10	3472.2
	Dummy	(18.45)	(−14.05)	(1.71)		(7.78)		(−11.86)			0.38	0.46
8.7	Fish	0.16		−0.28	0.11	0.31			0.25	0.09	0.08	3191.3
	Dummy	(5.38)		(−5.92)	(7.56)	(6.01)			(13.84)	(5.16)	0.37	0.46
8.8	Boat	0.73	−2.03	1.54	0.03	0.46		−0.20		−0.06	0.15	2112.3
	Dummy	(15.95)	(−8.85)	(6.17)	(2.51)	(9.97)		(−12.26)		(−4.11)	0.26	0.41

Note. The dependent variable in Eqs. 8.1–8.4 is the number of participation days, given that this number is nonzero. The numbers in parentheses are t values. Age, income, and recreation accessibility have been divided by 100 to produce comparable units with the dependent variable. The independent variables, Washington, Oregon, and Idaho are dummy variables. At most, two states would enter the model because if all three dummy variables were entered, the sum of these three column vectors would be a vector of ones and would be identical to the intercept column vector. R^2 is the coefficient of determination, $\bar{y}$ is the mean of the dependent variable, SER is the standard error of the regression equation, and F is the F statistic. Population data were obtained from the U. S. Bureau of Census [35].

population centroid and the likelihood that these trips will terminate at that recreation centroid. The accessibility of each recreation centroid is estimated by summing trips produced by all population centroids weighted by the probability of driving the distance to the recreation centroid. That is, recreation accessibility (RA_j) is

$$RA_j = \sum_{i}^{132} F_{ij} P_i \tag{9}$$

for the jth recreation centroid. Estimates from (9) were constructed for each recreation centroid in the region and for each of the four activities being analyzed. Recreation accessibility data are one input in the recreation attractiveness model.

U.S. Forest Service data on visitor days and facilities by ranger district were used with the accessibility data obtained from (9) to estimate the attractiveness model. As seen in Table II, the accessibility coefficients are positive and highly significant and, with the exception of river miles, the facilities coefficients are also significant. The accessibility coefficients indicate that use for each activity is greatest for those sites located near large production centroids. Since the equations are in multiplicative form and the accessibility exponents are positive, the responsiveness of use to facilities is positively related to the accessibility of a site. That is, for a given increment in facilities, demand will be greatest for those sites that are most accessible. Facility and accessibility data for each recreation centroid were substituted into (10) through (13) to estimate relative attractiveness of each centroid in the region.

The three inputs in the gravity model, P_i, A_j, and F_{ij} have been estimated with a trip-production model (8), a trip-attractions model (10)–(13), and by transforming the impedance matrix with the decay curves. The output of the gravity model is a trip-interchange matrix (T_{ij}) that gives the number of trips emanating from population centroid i with recreation centroid j as the destination. To illustrate the

TABLE II

Regression Estimates of an Attractiveness Model

Equation number	Regression equations	Coeff. of det. sample size
(10)	$A_{sj} = 0.006BF_j^{0.17}RA_{sj}^{0.76}$ (2.72) (2.12)	$R^2 = 0.26$ $n = 42$
(11)	$A_{cj} = 0.002CS_j^{0.53}RA_{cj}^{0.98}$ (5.10) (4.13)	$R^2 = 0.53$ $n = 49$
(12)	$A_{fi} = 0.004RM_j^{0.53}RA_{fj}^{0.71}$ (1.54) (2.22)	$R^2 = 0.13$ $n = 49$
(13)	$A_{bj} = 0.001BR_j^{0.60}RA_{bj}^{1.74}$ (4.33) (4.79)	$R^2 = 0.52$ $n = 37$

Note. The numbers in parentheses are t values. The dependent variables are activity days for swimming, camping, fishing, and boating, respectively. The first independent variable is the facility variable, which is linear designated beach feet (BF_j), camp sites (CS_j), acceptable river miles (RM_j), and boat ramps (BR_j). The second independent variable is accessibility for swimming, camping, fishing, and boating, respectively.

operation of the model, assume we wish to estimate the change in use and value of boating at a particular recreation centroid. First, the increased level of boating facilities (boat ramps) is substituted into the attractiveness equation (13) for boating and the predicted attractions ($\hat{A}_{bj}$) is substituted into the gravity model. A new trip-interchange matrix (T_{ij}) is estimated and the column vectors are used to estimate new boating demand curves for each site in the region and corresponding consumers' surplus. The demand curve for the improved site shifts outward and all other boating demand curves shift to the left. Empirically, though, only the demand curves for the substitute boating sites tend to shift left. The increment in use and consumers' surplus is the difference between the new and initial estimates.

II. EMPIRICAL ESTIMATES OF RECREATION — WATER-QUALITY BENEFITS

The purpose of this section is to present empirical estimates of recreation benefits of improved water quality for the degraded rivers in the Pacific Northwest. The Region X (Seattle) office of the U.S. Environmental Protection Agency has published a series of water-quality assessment reports covering each major river basin in the Pacific Northwest. Water quality was assessed for each major stream and for various reaches on these streams using both recreational and biological criteria. Water quality is indicated for recreation in general and is not estimated for each of the four activities analyzed in this paper. Water quality was not measured on a continuous scale; rather it was judged to be acceptable, objectionable, or not acceptable. An acceptable stream is one meeting the 1983 Federal water-quality goals of fishable and swimmable streams. Although standard water-quality parameters, for example, turbidity, were used in assessing water quality, professional judgment was also considered. The objectionable and not acceptable river stretches were noted on U.S. Geological Survey base maps for each of the three states. A planimeter was then used to tabulate degraded and acceptable river miles on a county basis. The resulting estimates of acceptable and degraded river miles serve as the basic water-quality inventory data for this study.

Given the assumption that water quality and facilities are perfect complements, it is feasible to estimate water-quality benefits by estimating the benefits of increasing facilities on degraded rivers. The number and type of facilities that could be constructed if water quality were improved were estimated by state recreation planners. The assistance of these planners was sought because of their first-hand knowledge of the recreational potential of the various areas in their respective states. The recreation planners were shown a U.S. Geological Survey base map of their state with the degraded rivers marked and asked the following question for each degraded river segment. "If water quality were improved, would this area be conducive to any of the four activities being considered here?" Where the answers were affirmative, the next question asked was, "How many facilities by type could reasonably be constructed along the degraded river?" This method of estimating the potential increment in facilities certainly lacks scientific rigor. However, all recreation-facilities data were obtained from the state recreation officials, and a major responsibility of recreation planners is to recommend the development of state recreation areas.

Based on these interviews with the state recreation planners, estimates were made of the potential increment in recreation facilities (boat ramps, swimming-beach feet, and campsites) that could be constructed at each recreation centroid if the degraded water were improved. The incremental variable that enters the model for fishing is degraded river miles by centroid. This variable was estimated with EPA data and did not require the assistance of the recreation planners. The estimated increment in facilities should be interpreted as the maximum potential change and not as an estimate of what would occur if water quality were improved. Recreation benefit estimates therefore represent an upper bound that can be attained only by cooperation with those responsible for planning and developing recreation sites.

Recreation demand and value were estimated for each of the four activities and for each of the 179 selected recreation centroids in the Northwest on the basis of existing water quality and level of facilities. Demand and value were again estimated assuming that all degraded water was made fishable and swimmable and the assumed facilities were constructed. The demand schedule for the improved sites shifts to the right, while the demand schedule for the unaffected sites remains unchanged or shifts inward if the site is a substitute for an improved site. Benefits due to improvement are defined as the willingness to pay for the improved site over and above what it was prior to improvement and they are measured as the area between the new and initial demand curves for the improved site. The decrease in willingness to pay at substitute sites does not and should not enter into the benefit calculations of the improved site. This position is reflected by Mäler [26], Mishan [28], Knetsch [24], Cesario and Knetsch [7], Freeman [18], and Sutherland [34].[15] The increment in benefits by county and by activity is presented in Table III.

The main result from Table III is that substantial incremental benefits, (e.g., over $1 million) are concentrated in a few counties and that most counties show much lower benefits. As expected, the counties with the largest potential benefits are those accessible to the largest populations. The Washington counties with the largest populations, in order, are King, Pierce, and Spokane, and these counties show corresponding large recreation benefits. In Idaho the second most populated county is Canyon, which shows the largest potential benefits. The most populated Idaho county is Ada, which shows zero benefits, but Ada has no degraded water.

Forty-five of the total 119 counties indicate zero total potential recreation benefits and several more show no benefits for certain activities. Of these 45 counties, 33 have no (officially) degraded water and therefore have no potential benefits. An additional 16 counties that have a water-quality problem were judged to be not conducive to recreation even if water quality were improved. These counties are typically rural counties where agriculture is the economic base.

[15] Mäler [26, p. 139] defines the willingness to pay for an improvement in environmental quality as the area between the initial demand curve and the demand curve reflecting environmental improvement and above the market price. Although Mäler does not explicitly address the issue of consumers' surplus foregone at substitute sites, Freeman [18] extends Mäler's analysis and concludes that "there is no need to take into account changes in recreation use at other sites or savings in travel cost" (p. 199). Freeman references Knetsch [24, p. 129] who concludes that the demand curve for the new facility must reflect existing facilities, but the loss in value of the existing facility can and should be ignored in calculating the net gain of the new facility. Mishan is equally emphatic when he states [28, p. 32] "I append a note... to reassure the reader that he should neglect induced shifts of demand of related goods." A theoretical demonstration of this position is provided by Sutherland [34].

TABLE III

Annual Recreation Benefits of Improved Water Quality by Activity and by County for Washington, Oregon, and Idaho

		Washington				
County	Degraded river (miles)	Swimming ($)	Camping ($)	Fishing ($)	Boating ($)	Total recreation benefits ($)
Adams	0	0	0	0	0	0
Asotin	50	2,074	95,704	21,786	10,805	130,369
Benton	203	12,250	0	141,909	0	154,159
Chellan	16	3,471	0	0	0	0
Clallum	31	8,578	0	0	0	3,471
Clark	0	0	0	0	0	8,578
Columbia	24	0	0	0	0	0
Cowlitz	0	0	0	6,062	5,134	11,196
Douglas	138	21,434	208,437	70,756	3,054	303,68
Ferry	231	2,189	46,917	70,946	0	120,052
Franklin	0	0	0	0	0	0
Garfield	5	0	0	0	0	0
Grant	84	6,277	148,178	68,517	0	222,972
Grays Harbor	84	23,384	0	49,596	0	72,980
Island	0	0	0	0	0	0
Jefferson	58	10,572	0	0	0	10,572
King	189	162,049	697,466	653,057	409,815	1,922,387
Kitsap	5	5,001	0	0	0	5,001
Kittitas	58	0	148,989	31,778	0	180,767
Klickitat	175	0	0	43,816	0	43,816
Lewis	84	22,021	0	103,552	21,430	147,003
Lincoln	0	0	0	0	0	0
Mason	0	0	0	0	0	0
Okanogan	141	48,921	50,084	121,295	13,074	233,374
Pacific	18	119	0	0	0	119
Pend Oreille	9	6,340	0	1,177	0	7,517
Pierce	95	55,041	431,020	588,689	128,626	1,203,376
San Juan	0	0	0	0	0	0
Skagit	15	100,506	0	0	0	100,506
Skamania	0	0	0	0	0	0
Snohomish	26	37,545	0	0	0	37,545
Spokane	63	133,482	119,149	65,807	38,811	357,249
Stevens	150	7,582	0	225,255	0	232,837
Thurston	61	102,383	0	234,223	652,041	988,647
Wahkiakum	0	0	0	0	0	0
Walla Walla	97	0	0	87,464	0	87,464
Whatcom	0	0	0	0	0	0
Whitman	7	398	0	0	0	398
Yakima	312	12,292	285,325	218,537	162,615	678,769
Total incremental benefits	2,345	$783,909	$2,231,269	$2,804,222	$1,445,405	$7,264,805
Total existing benefits		$31,719,145	$58,336,194	$57,313,978	$36,322,396	$183,691,713

TABLE III—*Continued*

County	Degraded river (miles)	Swimming ($)	Camping ($)	Fishing ($)	Boating ($)	Total recreation benefits ($)
			Idaho			
Ada	0	0	0	0	0	0
Adams	28	0	0	0	0	0
Bannock	24	349,318	0	0	0	349,318
Bear Lake	42	0	0	0	0	0
Benewah	0	0	0	0	0	0
Bingham	110	0	0	75,842	0	75,842
Blaine	104	0	0	81,925	0	81,925
Boise	5	0	0	0	0	0
Bonner	15	6,093	0	0	0	6,093
Bonneville	98	0	0	26,892	0	26,892
Boundary	0	0	0	0	0	0
Butte	170	79,105	0	92,103	54,741	222,949
Camas	29	0	0	0	0	0
Canyon	25	12,979	0	46,227	664,504	723,710
Caribou	61	51,587	0	0	0	51,587
Cassia	137	278,715	0	17,270	0	295,985
Clark	47	40,813	0	0	24,831	65,644
Clearwater	43	9,838	36,099	3,666	8,172	57,775
Custer	76	0	18,505	305,928	59,012	383,445
Elmore	12	0	0	0	0	0
Franklin	35	0	7,376	746	8,216	16,338
Fremont	115	46,244	0	7,635	0	53,879
Gem	0	0	0	0	0	0
Gooding	5	290,359	0	0	12,310	302,669
Idaho	82	0	0	0	0	0
Jefferson	55	0	0	195,827	597,612	793,439
Jerome	0	0	0	0	0	0
Kootenai	26	2,065	0	11,488	0	13,553
Latah	0	350	0	0	0	350
Lemhi	50	0	2,186	0	2,312	4,498
Lewis	0	0	0	0	0	0
Lincoln	60	114,518	0	94,668	74,088	283,274
Madison	28	0	0	55,090	410,597	465,687
Minidoka	0	0	0	0	0	0
Nez Perce	0	0	0	0	0	0
Oneida	32	133,919	0	27,913	14,574	176,406
Owyhee	400	0	0	48,521	9	48,530
Payette	0	0	0	0	0	0
Power	20	0	0	0	0	0
Shoshone	34	42,149	15,015	410	11,537	69,111
Teton	31	89,579	0	13,119	28,433	131,131
Twin Falls	127	160,049	0	129,397	0	289,446
Valley	55	0	0	0	11,263	11,263
Washington	40	3,195	0	12,173	88,549	103,917
Total incremental benefits	2,197	$1,710,875	$79,181	$1,246,840	$2,070,760	$5,107,656
Total existing benefits		$14,554,779	$14,366,061	$17,876,537	$23,642,556	$70,439,933

TABLE III—*Continued*

		Oregon				
County	Degraded river (miles)	Swimming ($)	Camping ($)	Fishing ($)	Boating ($)	Total recreation benefits ($)
Baker	0	0	0	0	0	0
Benton	94	374,954	0	305,814	0	680,768
Clackamas	79	39,242	0	0	71,613	110,855
Clatsop	0	0	0	0	0	0
Columbia	0	0	0	0	0	0
Coos	376	479	0	114,026	291	114,796
Crook	90	4,447	186,536	17,328	6,906	215,217
Curry	0	0	0	0	0	0
Deschutes	55	73,037	82,541	74,975	2,614	233,167
Douglas	316	59,943	255,167	402,602	38,474	756,186
Gilliam	0	0	0	0	0	0
Grant	43	0	0	0	0	0
Harney	434	0	8,233	28,933	0	37,166
Hood River	78	0	0	359,299	0	359,299
Jackson	0	0	0	0	0	0
Jefferson	23	0	0	0	0	0
Josephine	0	0	0	0	0	0
Klamath	72	0	2,212	4,488	0	6,700
Lake	34	0	0	0	0	0
Lane	227	0	276,242	421,713	0	697,955
Lincoln	145	0	27,880	317,620	0	345,500
Linn	123	14,632	0	75,450	5,121	95,203
Malheur	38	0	0	0	0	0
Marion	33	0	0	0	0	0
Morrow	0	0	0	0	0	0
Multnomah	17	179,059	0	30,976	0	210,035
Polk	79	68,074	0	270,545	212,712	551,331
Sherman	0	0	0	0	0	0
Tillamook	3	0	0	0	0	0
Umatilla	90	0	0	12,817	0	12,817
Union	32	0	0	0	3,194	3,194
Wallowa	0	0	0	0	0	0
Wasco	0	0	0	0	0	0
Washington	52	51,178	22,603	128,823	314,522	517,126
Wheeler	0	0	0	0	0	0
Yamhill	92	456,217	307,872	250,039	474,509	1,488,637
Total incremental benefits	2,614	$1,321,262	$1,169,386	$2,815,448	$1,129,956	$6,435,952
Total existing benefits		$15,618,870	$43,372,249	$36,960,534	$27,113,401	$123,065,054
Total regional incremental benefits	7,156	$3,816,046	$3,419,736	$6,866,510	$4,646,121	$18,748,413
Total regional existing benefits		$61,892,794	$116,074,504	$112,151,049	$87,078,353	$377,196,700

Zero or low benefits also occur for those counties that are significant distances from population centers. Even if water quality were improved and facilities added, demand would not increase significantly in those areas that are inaccessible. This result derives empirically from the attractiveness model that appears in Table II, and from the gravity model that allocates trips to close substitute sites.

A final explanation of the zero benefits is that water quality is assumed to be improved at a large number of sites where several sites may be close substitutes. Given the number of recreation trips, demand may actually fall for an improved site if a preferred site is also improved. If water-quality problem areas were analyzed individually, benefits would be substantially larger in those areas where benefits could be concentrated at one site instead of distributed across substitute sites. The policy implication of this result is that water-quality improvement efforts should be coordinated so as not to attract the same potential recreators.

The reliability of these results depends upon several assumptions, two of which should be emphasized: (1) where water quality is improved, the assumed increment in facilities must also be realized, otherwise the estimated benefits will not be obtained; and (2) those rivers that are officially degraded are assumed to be degraded for all four activities. Actually, some rivers that are objectionable for swimming may possess excellent fisheries and be quite suitable for boating.[16] The reliability of this study would be enhanced if water quality were estimated for each specific use of the water. Also, if significant recreation benefits are to be attained, water-quality improvement efforts should be coordinated between those state and Federal agencies that are concerned with the development of recreation facilities.

Since incremental benefits were estimated as the difference between existing benefits and benefits after assumed improvements, estimates of existing values are also available on a county basis. Existing benefits may also be construed as preservation values because, if water became so degraded as to become unusable, these values would go to zero.[17] Annual preservation values are presented for state totals at the bottom of Table III. Preservation values are significantly larger than potential increments for each activity and for each state. This result owes to the abundance of existing accessible recreation opportunities in the Northwest. The attractions model, (10)–(13), provides empirical evidence that the response of attractions to facilities diminishes as the level of facilities increases. The results in Table III cannot be extrapolated to other regions, which may have different population densities, existing recreation opportunities, and water-quality problems.

III. CONCLUSIONS

A model has been presented that can be used to estimate recreation benefits for four water-based activities within a three-state region. Benefits can be estimated for any single site or for several sites simultaneously. Benefits can also be estimated

[16]An official at the Washington State Department of Game confirmed that several officially degraded rivers in Washington are in fact excellent fisheries. Some of these rivers are fished intensively, and such activity would not increase significantly if water quality were improved.

[17]The TCM produces an ordinary demand curve that, for purposes of valuation, is presumed to be an income-compensated demand curve. When a demand curve is estimated with the TCM, a distinction cannot be made between compensating and equivalent variation. The direct-interview approach (contingency-value method) permits such a distinction. Most such studies, for example, Rowe *et al.* [29] have concluded that required compensation exceeds willingness to pay.

for preserving existing water quality as well as improving degraded water. The main conclusion is that, with respect to the three northwestern states, the largest potential recreation benefits exist near the population centers. In contrast, improving water quality in sparsely populated agricultural areas will probably not stimulate a substantial increase in recreation demand.

The benefit estimates in Table III may appear discouraging in terms of the economic viability of meeting the national goal of "fishable and swimmable" water. Indeed, improving water quality in some agricultural areas may not be cost-effective. However, certain nonrecreation benefits such as property values, aesthetic values, option demand, and perhaps drinking water and health benefits are likely to display the same geographic pattern as recreation benefits. That is, these potential benefits may also correlate with population densities. A more comprehensive analysis of benefits, focusing particularly on those listed above could conclude that total water-quality benefits are substantially larger than those presented in Table III.

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